The Orbit of Sirius. By S. W. Burnham.

With the addition of the recent measures of the companion to *Sirius*, we have data for defining the orbit within narrow limits of error. Previous to this time all the orbits of this system have been based upon a short arc described by the companion from 37° to 85°, and this, with the errors of observation which are necessarily found in all micrometrical work, is of itself insufficient for even an approximate result, since the observed positions of so short an arc can be equally well represented by many ellipses having little in common. Most of the computers doubtless have been more or less influenced in the selection of the ellipse to represent the apparent orbit by the period of the theoretical disturbing body as deduced from the variable proper motion shown in the meridian observations. In this instance that would result in the adoption for the apparent orbit of nearly the smallest ellipse which would represent the short arc of the observed positions. Consequently, of the twelve orbits which have been computed since 1880, using the measures up to the respective dates, with periods from 49·5 to 58·5 years, only three of them exceed 52·2 years, and most of them are not more than a year or two from the theoretical time.

The companion was last measured previous to 1896 by the writer with the 36-inch refractor at the Lick Observatory in the early part of 1890. Satisfactory measures were secured on several nights although the companion was seen with considerable difficulty. In the latter part of the same year, and again in the following year, it was invisible under the best conditions ; and Barnard in the two or three succeeding years was unable to see the small star with the same instrument.

All subsequent attempts to see the companion at Mount Hamilton and elsewhere with the largest telescopes down to 1896 October, resulted in failure. Two observers at the Lick Observatory, Hussey and Campbell, have placed on record the invisibility of the companion with the 36-inch on six nights in 1896 February and March. As it is stated that the atmospheric conditions on each night were good, and *Sirius* near the meridian in all the observations, it is probable that this failure to see the small star was due to the inexperience of the observers in double-star work, since it was easily found by Aitken with the same instrument less than eight months later, when the distance could not have increased more than 0″·2. Any form of orbit which would permit of a rapid increase in the distance at this point would be inconsistent with the prior measures.

The arc passed over by the companion from 1890 to 1896 is 170°, so that altogether we have a path of 255° for the motion of the companion since its discovery in 1862 by Alvan G. Clark ;

and this should be sufficient for the determination of the elements of the orbit with only a small percentage of error.

In my papers on *Sirius* in *Monthly Notices* for 1891 April and November, and 1893 June, I have collected and arranged in chronological order all the measures of the companion from its discovery down to my last measures in 1890; and from these observations have deduced twenty-nine yearly means for the position of the companion for each year from 1862 to 1890. These means were made with all possible care, and with due reference to the probable relative value of the individual sets of measures, based upon the number of nights, the experience of the observer in micrometrical and double-star work, the instrument used, and the apparent general value of the several series of measures when considered as a whole. This was all done in advance of any use of the observations for obtaining the orbit, and therefore wholly independent of any prejudice or theory concerning the period or anything else. From these yearly positions I found the apparent orbit given in the first paper referred to. The complete elements (*Mon. Not.* liii. 482; *Pub. Lick Observatory*, ii. 54, 239) are as follows :—

P = 51·97 years.	$i = 50°{\cdot}8$
T = 1893·5	$\Omega = 40°{\cdot}3$
$e = 0{\cdot}568$	$\lambda = 135°{\cdot}4$
$a = 8''{\cdot}31$	

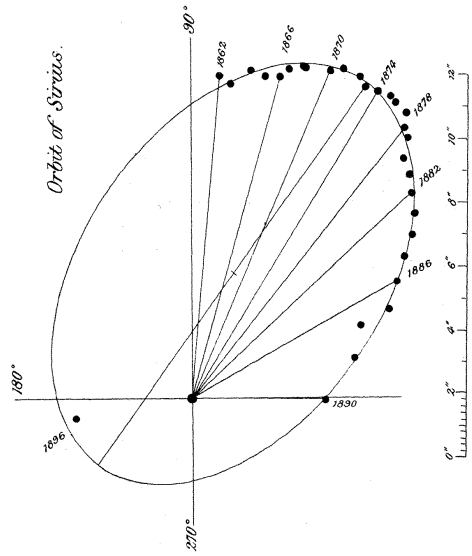
The fact that the companion could not be seen with the 36-inch in 1891, only six months after it had been measured in the early part of that year, was a certain indication that the form of the orbit in the fourth quadrant must be such as to require a rapid diminution in the distance of the companion at that point; and therefore, as stated in my paper at the time, nearly the smallest ellipse that would properly represent the measures was adopted as the most probable orbit. But for this consideration there was nothing to justify the investigation at all from such data, since an orbit with a period of several years more would have been equally probable, and would have represented the measures down to that time equally well.

The accompanying diagram (Plate 11) shows the yearly positions referred to, and the apparent orbit now determined from a careful consideration of all the available data. The only addition to the measures used in the former orbit is the following position derived from the measures on six nights by Aitken and Schaeberle, at Mount Hamilton :—

1896·85	189°·3	3''·71

From this ellipse I find the following elements :—

P = 51·80 years.	$i = 44°{\cdot}7$
T = 1893·77	$\Omega = 37°{\cdot}2$
$e = 0{\cdot}600$	$\lambda = 135°{\cdot}7$
$a = 7''{\cdot}62$	



Apparent orbit :—

Length of major axis	= 14″·48
Length of minor axis	= 9″·32
Angle of major axis	= 54°·4
Angle of periastron	= 251°·9
Star from centre	= 4″·09

In the following table will be found the corrections to the observed positions as required by the final orbit :—

	°	″		°	″
1862·20	−0·5	−0·20	1877·18	+0·4	−0·30
1863·22	−1·4	+0·14	1878·12	0·0	−0·07
1864·20	−0·2	−0·10	1879·02	−0·2	−0·09
1865·22	0·0	+0·20	1880·18	−1·0	+0·08
1866·21	+0·2	+0·30	1881·19	−0·5	+0·01
1867·17	−0·4	+0·18	1882·12	0·0	+0·01
1868·16	0·0	−0·01	1883·14	+0·6	−0·01
1869·17	−2·0	+0·17	1884·22	−0·1	0·00
1870·15	−0·2	+0·04	1885·19	−0·8	−0·08
1871·21	0·0	−0·01	1886·14	+0·6	+0·04
1872·22	+0·8	−0·10	1887·19	+0·5	−0·09
1873·21	+0·3	+0·12	1888·24	−4·1	+0·18
1874·19	+0·08	+0·02	1888·97	−0·1	+0·03
1875·22	+0·7	−0·18	1890·27	0·0	0·00
1876·22	+0·3	−0·19	1896·85	+1·3	+0·29

It will be seen that this differs but little from the orbit previously found. The change in the period is less than two-tenths of a year. Aside from the position of the companion in 1896 as required by this orbit, I have no doubt that the distance of that year was undermeasured, and that it will be found hereafter that the above tabular correction is not too large. Remembering the appearance and difficulty of the companion in 1890 with the same instrument, when the distance could not have been much less than 4″·2, and the fact that I failed to see the companion at all a few months later, it appears to be improbable that the distance in 1896 was less than 4″.

The following is a short ephemeris of the companion :—

	°	″		°	″
1898·20	172·5	4·4	1900·20	151·0	4·9
1899·20	161·0	4·6	1901·20	141·1	5·2

With the extended arc given by the measures of 1896, there is but little latitude in the selection of the apparent ellipse. Of course, everything depends upon the substantial accuracy of the

last position, and especially with reference to the angle, because all the preceding positions can be represented by other ellipses. If the correctness of this position is confirmed by future measures, as it doubtless will be, there can be little change in these elements.

A New Quadruple Stellar System. By R. T. A. Innes.

The star κ *Toucani* was discovered to be double by Sir John Herschel on the night of 1834 November 3 with his 18-inch reflecting telescope. He remarks, "Very beautiful, excellent and careful measures with power 320 and triangular aperture."

His reflector measures are—

1834·84	12°·0	2″	$6\frac{1}{2}$ and 9
1834·90	11·3	$2\frac{1}{2}$	6 ,, 9

He measured it again in 1836 with his 5-inch refractor, getting

1836·64	17°·8	5″·78	$5\frac{1}{2}$ and 11
1836·91	14·2	4·24	$6\frac{1}{2}$,, 10

Amongst later measures may be cited

1871·9	0°·0	5″·19	H. C. Russell, Sydney.
1894·9	354·8	5·52	John Tebbutt, Windsor, N.S.W.

The comparison is also to be found in the Cordoba General Catalogue, being called 7th magnitude there.

The magnitudes may be taken as 5·6 and 7·8, the companion being of a purple colour.

The above measures alone would not prove physical connection, but the large proper motion of κ *Toucani* 0″·407 towards 86°·2 puts it beyond doubt.

The star Lac. 353, mag. 7·3, is 5′ 20″·0 north preceding κ *Toucani*. Whilst observing it in 1895 with a reflecting telescope made by Mr. F. Dixon Edmonds, an amateur, residing in Sydney, I noticed that it was also a double star (No. 27 of the list given on p. 262 of vol. vi. of the *Journal of the British Astronomical Association*).

An estimate made at that time gave

1895·8	180°	1″ ±

and one made here with the 7-inch refractor is

1896·8	185°	1″·4 ±

magnitudes 7·7 and 8·7.